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THE INFLUENCE OF MACROECONOMIC VARIABLES IN PORTUGAL HOUSE PRICES: A FACTOR AUGMENTED VECTOR AUTOREGRESSIVE (FAVAR) APPROACH

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Abstract

This paper tries to evaluate the impact of a set of macroeconomic variables on house prices in Portugal, using a factor-augmented vector autoregressive (FAVAR) model which, as opposed to a standard VAR, allows to incorporate a large number of time series by condensing it in a small number of factors. To estimate the model, a large data set of 134 quarterly series over the period between 1995:Q1 and 2017:Q2 was employed. The findings reveal that there is little difference between the models specification used in this study. However, it is shown that the FAVAR allows for a better interpretation and examination of the different variables' impulse responses than the typical VAR.

Keywords: Real house prices, FAVAR, VAR.

I. Introduction

The recent European downturn attributed to the sovereign debt crisis has changed the economic perspectives of the future. During this period, several European nations faced the collapse of their financial institutions and a significant increase in government debt which, combined with a major confidence crisis, lead to the default of some countries and consequent bailout by the International Monetary Fund (IMF). Portugal was one of the countries that faced this situation. Naturally, the economic impact was significant and the real estate market suffered a sharp decline between 2011 and 2013. According to Stock and Watson (2003), house prices are prime indicators for economic activity, giving a perception on where the economy is heading. Interestingly, housing markets have been recovering at a high pace, with an accumulated growth of 25% since 2013. Although this seems to be an encouraging development for the Portuguese economy, European and international institutions are apprehensive as this increase may not be complemented by economic growth, which may lead to internal imbalances.

This paper examines the explanatory power of including additional data from a large set of economic variables that potentially affect house prices, using a factor-augmented VAR (FAVAR) approach, as proposed by Bernanke et al. (2005). This model considers 134 quarterly series from 1995:Q1 to 2017:Q2. Most recent studies, frequently related with monetary policy, have implemented the standard vector autoregressive (VAR) model due to its ability to recover shocks and reflect response changes on the selected identified variables. However, the small-scale nature of VAR models, with a limited information set, restricts the ability of policymakers to understand the full impact of monetary policy decisions on macroeconomic variables. In fact, these models typically do not contain more than six to eight variables to ease the loss of degrees of freedom. Thus, employing such limited information set has been accountable for what is known in the literature as the “price puzzle”. It states that the policymaker may reach to

inadequate and sometimes misleading results, predominantly due to this information insufficiency. Therefore, as a large number of indicators potentially affect the housing market, one should use the FAVAR approach in order to have a broader perspective of the study ahead.

This paper is organized as follows: section II presents a literature review of recent studies that employed FAVAR models, giving their main ideas and findings; section III approaches the economic theory, introducing the topic and stating the expected results; section IV explains the data used in this study and the transformations made to accommodate the model; section V introduces the estimated model, its restrictions and advantages; section VI characterizes the empirical implementation, where Stata was used, and the respective empirical results, as well as interpretation of the relevant findings; and finally, section VII provides some concluding remarks, summing up the main points of this paper and providing some suggestions for future researchers.

To the best of the author´s knowledge, there is no study that investigates the impact of macroeconomic variables on housing prices in Portugal using a FAVAR model. This paper's goal is to analyze the reaction of house prices to macroeconomic shocks and the factors that affect the variation in these responses.

II. Literature Review

Berggren and Lodenius (2016) investigated the usefulness of a FAVAR, estimated by principal component (PC) analysis, to forecast the monthly inflation rate in Sweden. They produced 42 forecasts between January 2012 and June 2015 and found that the FAVAR did not meaningfully improve the forecasts when compared to a univariate model.

Berggren (2017) studied the FAVAR's different factor estimation methods. More precisely, he examined the frequently used principal component approach, the common correlated effects

method and a likelihood-based technique using Gibbs sampling. He used a large data set of Swedish variables from 1998 to 2016 and concluded that the likelihood-based method leads to unreliable outcomes. Moreover, his findings show a certain similarity between the PC-based and the CCE-based methods.

Bork (2009) estimated a FAVAR to characterize the effects of economic shocks to the US federal funds rate. Hence, a state space model with 120 US macroeconomic and financial time series was employed. In opposition to Bernanke et al. (2005), he estimated the FAVAR using a fully parametric one-step expectation-maximization (EM) algorithm, and not the common two-step PC approach or one-step Bayesian method. The distinctive feature of the EM algorithm is that it allows not only to estimate all the parameters and the dynamic factors simultaneously but also to rely on classical inference. His findings show that the lower the number of factors used in the FAVAR, the greater will be the lags needed to achieve a well specified model and vice versa.

Chow and Choy (2009) expanded a monetary VAR model with common factors obtained from a large panel dataset covering 122 economic time series between 1980 and 2008. Their objective was to measure the effect of monetary policy shocks on residential property and stock prices in Singapore and it was established that monetary policy can be seen as a mechanism to smooth asset price fluctuations.

Eickmeier, Lemke and Marcellino (2011) proposed a classical approach to estimate FAVAR models, using time variation in the factor loadings, in the factor dynamics and in the variance-covariance matrix of innovations. This allowed the combination between the benefits of using large time series with a time-varying model structure. They used a large quarterly dataset of US variables from 1972 to 2007, to assess how monetary transmission has evolved during that

period. Their findings show evidence that projections from time-varying FAVAR models are more precise than those from a continuous parameter model.

Fernald, Spiegel and Swanson (2014) estimated the Chinese economic activity and inflation as latent variables, using a wide set of economic indicators and a dynamic factor model approach. Then, they incorporated these latent variables in a FAVAR to study the effects of Chinese monetary policy on the economy. Consistently with economic theory, they found that increases in bank reserves' requirements impact negatively both on economic activity and inflation. However, and in contrast with most literature, they also discovered that changes in interest rates have significant impact on those indicators, while other measures of changes in credit conditions do not. Overall, their results indicate that China's monetary policy transmission channels are converging to American and European market economies.

Gabriel and Lutz (2014) used a structural FAVAR with a large dataset of daily time series to analyze the impact of unconventional monetary policy on housing, real estate and related markets. Their discoveries show that an unconventional expansionary monetary policy decreases key housing market interest rates, rises equity market returns for homebuilders and real estate investment trusts, lowers the cost to insure subprime mortgage-backed and commercial real estate debt and reduces housing distress. Furthermore, they also found evidence suggesting that the impact of unconventional monetary shocks are asymmetric across risk-levels and geographies.

Gupta and Kabundi (2009) analyzed the impact of monetary policy on house price inflation in the United States and South Africa, using a FAVAR, estimated based on a large data set containing quarterly series over a few years' period. They found that, generally, house price inflation reacts negatively to monetary policy shocks.

Gupta, Kabundi and Miller (2011) studied the impact of adding information from a large set of economic variables that potentially affect house prices, using dynamic factors or Bayesian shrinkage approaches. They compared the out-of-sample forecasting performance of various time-series models (VAR, FAVAR and Bayesian time-series models with spatial priors) and concluded that the spatial factor augmented (BVAR) models were the best performing models, explaining half of the states analyzed in the US. Although the FAVAR achieves the lowest variability across states, it does not outperform the VAR in terms of forecast ability. Their research shows mixed evidence on the role of macroeconomic fundamentals in improving the forecasting performance of time-series models, as only for thirteen states the forecast enriched the analysis and not for the remaining seven.

Hansen and McMahon (2015) explored empirically the channels through which central banks communication produce effects. More specifically, they analyzed the impact of the Federal Open Market Committee (FOMC) announcements on markets and real variables. They found that, despite the greater importance of central bank management on future interest rates than the communication of general economic conditions, neither of the above have especially effects on the real economic variables included in the FAVAR.

Iacoviello (2005), Case et al. (2005), Iacoviello and Neri (2007), and Vargas-Silva (2008) demonstrate a solid connection between housing market and economic activity in the US.

Senbet (2016) studied whether the monetary policy operates predominantly through the traditional interest rate channel or the credit channel, using a FAVAR. He analyzed 154 US monthly variables between 1970 and 2014. His results validate the presence of the credit channel, meaning that, following a contractionary monetary policy, banks, by reducing the amount of credit (loans) in the economy, will contribute to lower consumption and investment,

and consequently, reduce economic activity. However, the traditional channel still occurs, since the impact of a decline on bank' loans is smaller than the impact of a rigid monetary policy.

III. Economic Theory

Housing market has significant importance on households' wealth and consumption decisions. In fact, housing typically symbolizes their largest single purchase and subsequently, is considered as the main representative of consumer wealth. Moreover, changes in house prices can produce substantial effects on the local economy.

Like any other good, houses are subject to the basic economic principle of the law of supply and demand. Evidently, there are several indicators that influence housing demand and supply. Firstly, and foremost, prices represent the initial stage of consumers' decision when buying a house. If prices decrease there will be more demand and less supply and vice versa. Then, concerning demand, there are non-price determinants like population, households' income, interest rates (mortgages), credit accessibility and conditions and expectations regarding future prices and economic conditions. On the supply side, determinants such as availability of factors (land), building costs (raw materials and labor), government legislation (permissions to construct) and subsidies (support for more affordable homes), also affect the housing market.

The real estate market (not only housing) has, theoretically, strong links with the country's economic perspectives and reality. When a nation is in a challenging economic and financial situation, usually two contrasting consequences may arise. The first and more common one, is that both due to the uncertainty regarding the future and the almost guaranteed bank credit decline, the demand and prices for housing will fall. On the other hand, some investors may see this as an opportunity. Since in such times interest rates are unappealing, the housing market is seen as a way to increase investors' wealth. In fact, with low interest rates, people with excess

resources will achieve a better rate of return by investing in real estate rather than from a banking product. Ultimately, this will lead both demand and prices up.

More specifically, the relationship between house prices and the real economy can be intensified in the presence of financial imperfections. This increase essentially occurs through the financial accelerator and associated instruments operating through households, firms and nations' balance sheets. In accordance to these instruments, a rise (decline) in asset prices, expands (deteriorates) an entity's net worth improving (deteriorating) its capacity to borrow, invest, and consume. This procedure, can lead to further escalations (reductions) in house prices and originate general equilibrium effects. In other words, disruptions in housing markets can convert into greater cyclical fluctuations in the real economy.

IV. Data

From economic theory, one knows that the housing market is affected by several macroeconomic indicators such as income, prices, credit conditions and consumer preferences. Therefore, it is necessary to use an extensive data set that combines all these determinants, allowing for a broad outlook and complete analysis.

To achieve the purposes of this study, a series of 134 quarterly data spanning between 1995:Q1 and 2017:Q2 was considered. The selection of the sample period is given by the accessibility of the data obtained from Bank of Portugal and OECD databases. The data set comprises, among others, indicators of economic and consumer trust, economic and financial situation in the last 12 months, unemployment expectation for the future, turnover in some major industries, energy consumed, total imports and exports, the real effective exchange rate index, PSI-20 index, interest rates, labor force and population.

Moreover, quarterly series of GDP, house prices, credit indicators, disposable income, 10y-3m interest rate spread and mortgage interest rate for the period were also considered in this analysis. The emphasis on this sample is explained by the fact that provides a broad perspective of fluctuations on the housing market in Portugal.

A principal component analysis (PCA) methodology was applied to extract the relevant information from those set of variables. This represents a non-parametric technique for gathering data from large sets and uses an orthogonal transformation to transform a set of probably correlated variables into a set of linearly uncorrelated ones, named principal components. The point is to have the maximum variance amount of the original variables explained by a minimum number of components, losing as little information as possible.

As indicated in the model displayed in equation (2), it is assumed that all variables in X_t are stationary. For this purpose, they were all subject to unit root tests, employing the commonly used Dickey-Fuller test. When a unit root is found, transformation is made to achieve stationarity. The possible transformations include differencing the data, taking logarithms, or both.

Lastly, all final data series are transformed such that each variable is expressed in standard units, i.e., each variable has zero mean and a standard deviation of one. This is especially useful in our case: since many variables have different scales, it is preferable to consider innovations measured in standard deviation units rather than in unit shocks.

V. The FAVAR Model

As previously indicated, most studies regarding economic policy base their analysis on the impulse response functions obtained from conventional VAR models. Nevertheless, these models suffer from major limitations: first, due to the information insufficiency in VAR analysis, when comparing with central banks information requirements, the policy shocks and

respective responses are expected to be contaminated; second, as it is hard to quantify general economic concepts like "economic activity", it will most likely lead to measurement errors; and finally, the fact that impulse responses can only be observed for the limited variables included in the VAR, which represent a much smaller subsection of the variables that concern to policy makers.

To overcome these issues, a factor-augmented vector autoregressive (FAVAR) model will be employed, an instrument for examining macroeconomic data popularized by Bernanke et al. (2005). The FAVAR approach improves the examination by summarizing an additional and richer information set into a small number of factors, using a principal component analysis (PCA)[1].

Let Y_t be a $M \times 1$ vector of observable economic variables presumed to drive the dynamics of the economy. Differently from the conventional VAR approach having Y_t alone, it was included a variable that captures additional economic information that may be appropriate to model the dynamics of these series. Therefore, let F_t be a $K \times 1$ vector of unobserved factors, which provide further economic data not fully captured by Y_t.

The joint dynamics of (F'_t, Y'_t) is represented by the following equation:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + v_t \quad (1)$$

where Φ(L) represents a conformable lag polynomial of finite order p and v_t is the error term with zero mean and a covariance matrix Q.

[1] Two main approaches exist in the literature to estimate FAVAR: a two-step principal component and a single-step Bayesian likelihood. Although Bernanke et al. (2005) failed to find any particular differences between the two in terms of inference, the principal components approach appears to be predominant in empirical studies.

Equation (1) is a standard VAR and specifies a way of quantifying the contribution of the additional information comprised in the factors F_t. However, as the vector of factors F_t is unobserved, we cannot use typical economic techniques to estimate the model. The appropriate method to estimate the model is by using factor analysis as proposed by Stock and Watson (1998). Assuming that the factors effectively summarize information from a large set of economic time series, let X_t be a Nx1 vector of "informational" time series, with $N \geq M + K$.

Assume also that X_t is related with the unobservable factors F_t and the observed variables Y_t as follows:

$$X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t \quad (2)$$

where Λ^f and Λ^y are $N \times K$ and $N \times M$ matrices of factor loadings, respectively, and e_t is a $N \times 1$ vector of error terms, that are weakly serially and cross-sectionally correlated with zero mean.

Equation (2) exemplifies the notion that both Y_t and F_t are joint forces that conduct the dynamics of X_t. This equation, without observable factors, is what Stock and Watson (1998) described as dynamic factor model.

As for the estimations of F_t', Bernanke et al. (2005) suggested two distinctive approaches: a two-step principal component estimation and a joint estimation of equation (1) and (2) using a likelihood-based Gibbs sampling technique. For the two-step estimation, Bernanke et al. (2005) make a contrast between "slow-moving" and "fast-moving" variables in X_t. The distinctive characteristic is that the former does not react contemporaneously to shocks, while the latter reacts instantly to variations in monetary policy or economic activity. However, as the purpose of this study is not to analyze the effect of monetary policy, no distinction is given to the variables in X_t.

VI. Empirical Implementation and Results

As stated before, the variables were initially transformed, when required, to induce stationarity. The next step was to estimate the VAR, using real house prices, real GDP and real mortgage rate as observable variables. Note however that, by merely using these variables, the information that is possible to extract from the impulse response functions is very limited. This is why there is a need to expand the VAR analysis using factor analysis. Still regarding the VAR specification, it was identified in a standard recursive way, by ordering the real house prices' variable last and considering its innovations as the shocks proposed for analysis. Additionally, the VAR was estimated with a lag of four, as indicated by the *varsoc* command in Stata. Finally, a time span of 20 quarterly periods (5 years) was chosen, to allow for long-term observation.

In accordance to what Bernanke et al. (2005) did, a FAVAR approach was employed with two different specifications: the first, by adding to our initial three-variable VAR one factor, enabling the examination of the marginal contribution of the additional information; the second, a one-factor FAVAR specification with a unique observable variable, the real house prices. As previously stated, the principal component estimation method was chosen. Thus, the *pca* command was used to estimate the factors, as initially proposed by Stock and Watson (1998). The optimal number of factors is a somewhat subjective choice. Nevertheless, K=1 and K=3 were selected, which explained 91,70% and 95,74% of the time series' overall variance, respectively. Then, the impulse response functions were generated.

Figure 1 displays the impulse response functions of real GDP, real mortgage rate and real house prices, given a shock in the latter. It is possible to verify that the 3 specifications give similar results for each variable, which one may find surprising. In fact, the two FAVAR specifications do not produce significantly distinctive responses, giving the idea that the additional

information contained in the factor included in both models was irrelevant. However, there is one considerable advantage of employing a FAVAR: it allows to recover the impulse responses of all variables included in the factor estimation, while the standard VAR only allows for the variables included in the model (in our case, the ones shown in Figure I). It is also interesting to see that the responses of the one-factor FAVAR with one observable variable are identical to the one of the one-factor FAVAR with three observables. This suggests that the former captures relevant information regarding economic activity and interest rates, despite no such measure is forced as an observable factor.

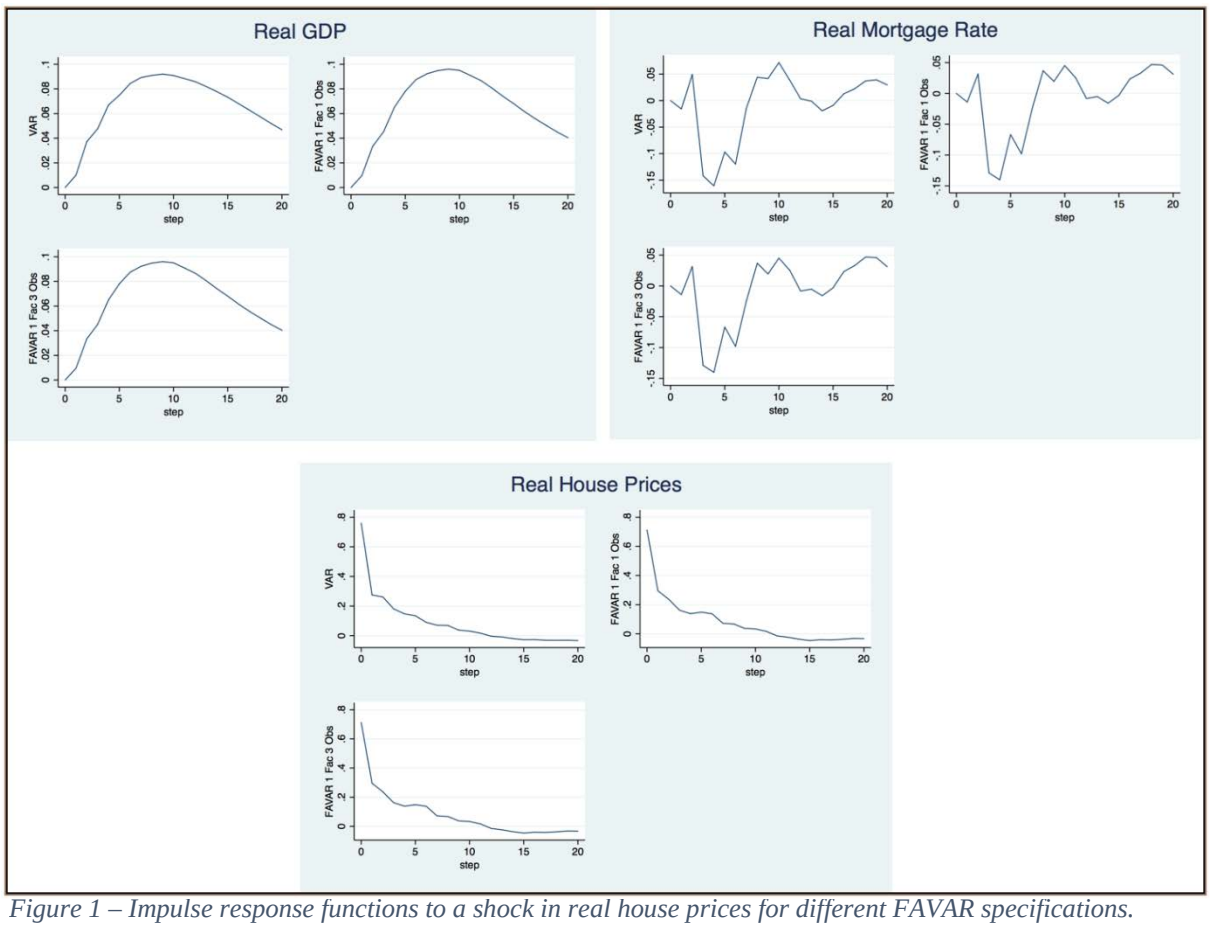

Figure 1 – Impulse response functions to a shock in real house prices for different FAVAR specifications.

Still regarding Figure 1, it is possible to verify that, contrarily to the effect of house prices on GDP, the effect on mortgages rates symbolizes a price puzzle. Indeed, GDP has a positive correlation with a variation in the housing market and after two years (8 steps in the graph), it converges towards zero. Nonetheless, in a primary stage, mortgage rates seem to move in an opposite direction of the house prices. This is questionable because, following economic theory,

it is expected that, the higher the average house prices the higher will be the mortgages and consequently, the higher will be mortgage interest costs for any given interest rate. Yet, after some periods, the direction shifts and the effect disappears in the long-run, converging to zero.

As previously mentioned, an advantage of using the FAVAR approach is the possibility to analyze the impulse response functions of all variables included in the information set, i.e., for all elements included in X_t. Figure 2 shows that, with a three-factor FAVAR, our initial variables converge more rapidly to zero, when comparing to the one-factor specification. This means that it was possible to extract further relevant information that complemented the one previously obtained by the initial FAVAR.

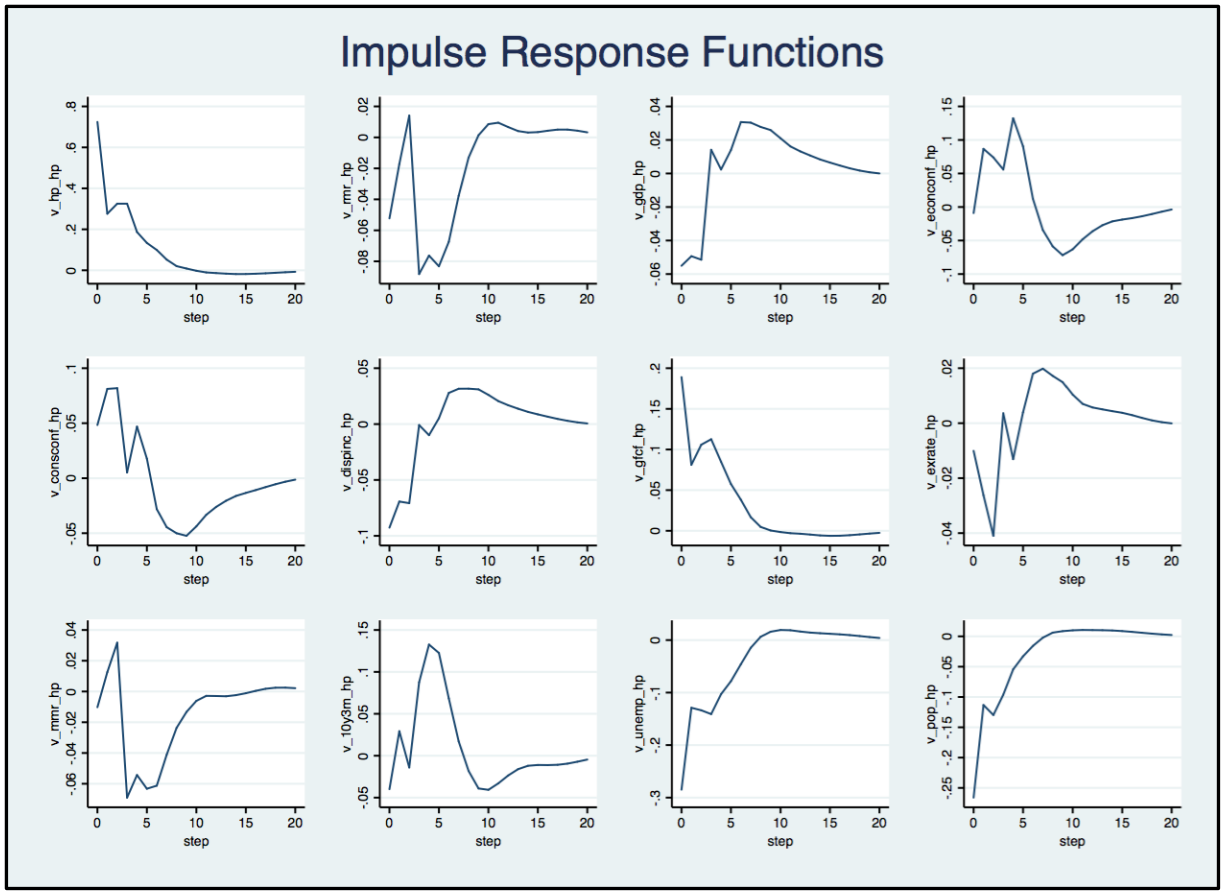

Figure 2 – Impulse responses from a three-factor FAVAR with one observable variable.

Figure 2, in addition to the three initial variables, also illustrates the effect of house prices on the following indicators, ordered from left to right: economic confidence, consumer confidence, disposable income, gross fixed capital formation, real effective exchange rate index, money

market rate, 10y-3m spread, unemployment and population. Notice that only 12 responses of all 134 variables included in the information set are presented. Analyzing those responses, one may see that they correspond mainly to what would be expected. Real activity indicators have positive correlation with our shock, while indicators such as investment (GFCF) have an opposing direction. In fact, as the housing market becomes more appealing, its price increases which leads to a lower investment. Moreover, unemployment and population have very similar responses, which may be considered a puzzling result. Following economic theory, an increase in unemployment will lead to a decrease in housing search by individuals. Only the effect on population seems correct: as population grows, so does the housing' demand.

For a study aiming to address this type of analysis, there is the need to choose the appropriate number of factors to include in the FAVAR model, maximizing the probability of capturing all relevant information from the data set. As there is no right answer to this question, the above factors were chosen. Furthermore, 5 factors were also employed, just like in Bernanke et al. (2005), but the results did not change in a qualitatively relevant manner.

VII. Conclusion

This study attempted to analyze the effects of shocks in Portugal's housing market on several macroeconomic variables, using different FAVAR specifications. The usage of this method allowed the aggregation of numerous time series into a reduced number of factors, that otherwise could not be used by a standard VAR.

In fact, the VAR model, in addition to the problems associated with the degrees of freedom, can also lack of relevant information, lead to measurement errors when defining general economic concepts and limit the impulse responses that are possible to recover.

The results show little difference between the FAVAR specifications, showing that a small number of factors is capable of explaining almost all variance from the original time series. Moreover, and more surprisingly, it was demonstrated that the VAR responses are very similar to those of a one-factor FAVAR. However, this does not mean that the factors did not add any relevant information, since with this method it is possible to improve the analysis by studying the impulse responses of all variables included in the information set and not only the ones included in the original VAR. For that reason, the FAVAR represents a more capable model for policy makers and central banks when analysing economic fluctuations and monetary policy concerns.

For future research, some alternative methods for studying the effects of shocks in house prices may be carried out. For example, like in Bernanke et al. (2005), one may use the Gibbs sampling technique, instead of the chosen one for this study, the principal component approach. Moreover, one may also employ different identification methods or different estimation procedures of both VAR and FAVAR.

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